Glass	Lifetime, μsec	Quant. yield, rel. units	Stim. emiss. cross sect., 10^{-20}cm^2
Silicate glass	550	1.0	2.5
Quartz glass	420	0.75	2.5

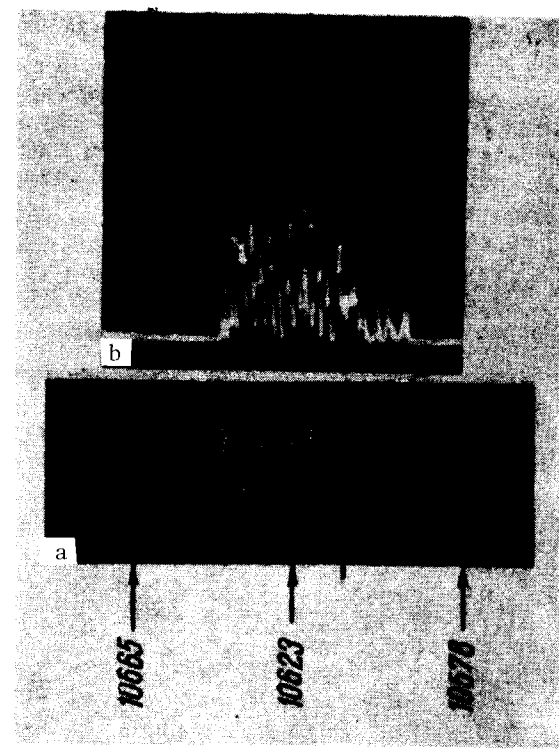

Fig. 2. a) Generation spectrum of quartz glass with Nd at fourfold excess over threshold; b) oscillogram of generation intensity of quartz glass with Nd at slight excess above threshold, T = 300°K.

of purer initial materials and of sterile fusing conditions will greatly imrpove the generation parameters.

It should be noted in conclusion that the investigated samples retain the main advantages of quartz glass, namely the high thermal endurance (higher than 800°C) and transparency in the ultraviolet. The latter makes it possible to use the ultraviolet absorption bands of neodymium for the pumping. The high thermal endurance of the quartz glass gives grounds for hoping to realize continuous lasing with relatively simple cooling conditions.

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COHERENT EFFECTS IN THE PROPAGATION OF AN ULTRASHORT LIGHT PULSE IN A MEDIUM WITH RESONANT TWO-PHOTON ABSORPTION

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An exact solution is obtained for the problem of the propagation of a light pulse of duration $\tau_p << T_2$, under conditions of two-photon resonance ($2\omega = \omega_{21}$). It is shown that the decomposition of the initial pulse into a number of components followed by a reduction of the component duration can be used to obtain sequences of ultrashort pulses of duration $\tau_p \leq 10^{-14}$ sec.

Coherent transparentization (bleaching) of substances by propagation of ultrashort light pulses having a doubled carrier frequency (2ω) close to the frequency ω_{21} of the resonant transition in the medium have been under investigation recently both theoretically [1, 2] and experimentally [3].

This bleaching differs qualitatively from the usual absorption saturation, and can occur only under the conditions

$$\tau_p < T_2, \qquad \theta_0 = \frac{|r_{21}|}{2\hbar}\int_{-\infty}^{\infty} \mathcal{E}^2(0, t)\,dt \geqslant 2\pi, \tag{1}$$

where τ_p is the pulse duration, T_2 is the polarization relaxation time, $\mathcal{E}(0, t)$ is the amplitude of the field as it enters the medium, and r_{21} is the composite matrix element of the two-photon transition [1]. Physically this means that the energy absorbed by the matter from the pulse can then return coherently to the field by stimulated emission. In [1, 2], only the feasibility of this effect under the conditions (1) is indicated, and the space-time evolution of the pulse moving in the medium is not considered. In the present paper we study the complete evolution of the pulse in the case when the absorption line of the medium is homogeneously broadened and two-photon resonance takes place ($2\omega = \omega_{21}$). In this case the rigorous self-consistent system of the material equations and Maxwell's equations [1, 4] can be reduced by simple transformations to the form

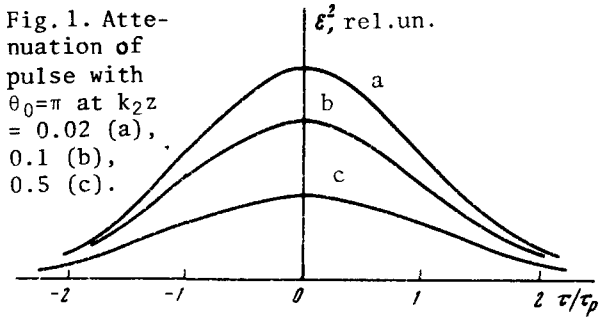

Fig. 1. Attenuation of pulse with $\theta_0=\pi$ at k_2z = 0.02 (a), 0.1 (b), 0.5 (c).

$$\frac{\partial^2\Psi}{\partial z\partial t} + \frac{n}{c}\frac{\partial^2\Psi}{\partial t^2} = -2k_2\frac{\partial\Psi}{\partial t}\sin\Psi, \tag{2}$$

where $\Psi(z, t) = |r_{21}|/2\hbar\int_{-\infty}^{t}\mathcal{E}^2(z, t')dt'$, n is the refractive index, $k_2 = (2\pi\omega/nc)N|r_{21}|$, and N is the density of the particles in the medium. We note that $\Psi(0, \infty) = \theta_0$. Equation (2) with allowance for the boundary conditions admits of the following exact solution in terms of the field amplitude:

$$\mathcal{E}^2(\tau, z) = \frac{\mathcal{E}^2(0, \tau)}{1 + 2k_2z\{\sin\Psi(0, \tau) + k_2z[1-\cos\Psi(0, \tau)]\}} \tag{3}$$

where $\tau = t - (nz/c)$. A simple analysis of this solution shows that at $\theta_0 > 2\pi$ there exist poles in the complex plane, and these poles approach the real axis with increasing traversed distance z. This leads to the appearance of strong oscillations within the pulse. The calculation by means of formula (3) is illustrated in Figs. 1 — 3. Whereas a pulse with $\theta_0 = \pi$ attenuates in accordance with the usual rule for two-photon absorption, the "2π" pulse (Fig. 2) propagates without distortion with a velocity $v < (c/n)$, as predicted in [1]. The most interesting effects are produced by motion of a high-power pulse ($\theta_0 > 2\pi$) (Fig. 3). We see that although the total energy of such a pulse changes little, sharp peaks are produced inside the pulse, and their duration decreases on propagating to the interior of the medium. It is important that the "area" occupied by each peak remains approximately constant and corresponds to $\theta = 2\pi$, so that the instantaneous power in the peak increases sharply. This is explained physically by the "erosion" of those parts of the pulse which interact with the particles in the absorbing state, and the return of the energy to the field via two-photon stimulated emission, which leads to an increase of the maxima. It is easily understood that, unlike one-photon resonance, the two-photon interaction is proportional to the square of the field amplitude $\mathcal{E}^2$, and that once the power resonances are produced, they are not stabilized but continue to increase. In the calculation model used above, this growth is not limited by anything. In a real situation, however, there are a number of limitations, the

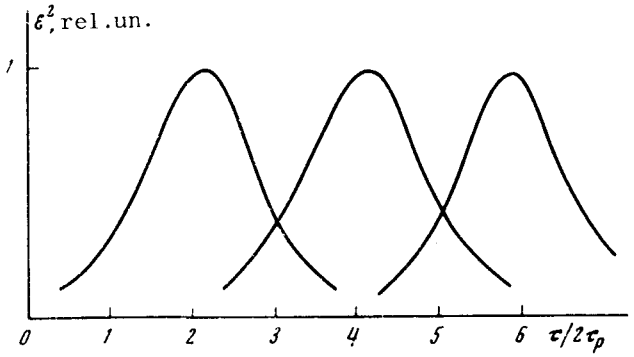

Fig. 2. Motion of stationary 2π pulse: a) k_2z = 2, b) k_2z = 4, c) k_2z = 6.

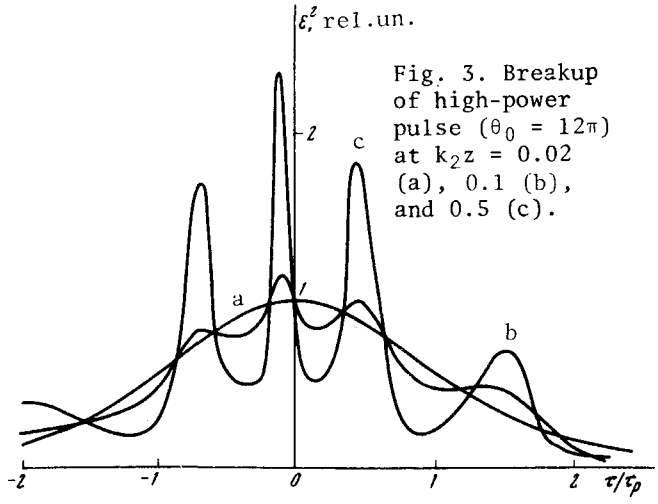

Fig. 3. Breakup of high-power pulse (θ_0 = 12π) at k_2z = 0.02 (a), 0.1 (b), and 0.5 (c).

most important among which is multiphoton ionization and cascade breakdown. According to [5,6], these effects do not arise if the following conditions are satisfied:

$$\theta_0 \leqslant \frac{10^2 |r_{21}| m\omega^2 l}{e^2 h\nu}, \qquad \tau_p \gtrsim 10^{15/\alpha}\left(\frac{e^2\hbar\theta_0}{2|r_{21}| m\omega^2 l}\right)^{\frac{\alpha+1}{\alpha}}, \tag{4}$$

where I is the ionization potential of the atoms of the medium, ν is the frequency of the elastic collisions of the electrons with the atoms, and α is the integer part of the radio $I/h\omega$. The first condition of (4) limits the pulse energy as a result of the onset of cascade breakdown, while the second limits the pulse duration as a result of multiphoton ionization. At $\omega^2 \simeq 2\times10^{30}$ sec^{-1} (neodymium laser), I = 6 eV, $|r_{21}| \sim 4\times10^{-24}$ cm^3, $\alpha = 6$, and $\nu = 10^9$ sec^{-1} ($N = 10^{16}$ cm^{-3}) (which is typical of alkali-metal vapors), the limiting value is $\theta_0 \leq 10^4$. If one applies at the entrance of a gas cell with the indicated characteristic a pulse with light-flux density $q \sim 10^9$ W/cm^2 and duration $\tau_p \sim 10^{-9}$ sec (with $\theta_0 \sim 10^2$ and $T_2 = 10^{-8}$ sec), then its components, in accord with the second condition of (4), can be narrowed down to $\sim 10^{-13} - 10^{-14}$ sec^{-1} before multiphoton ionization sets in. The corresponding cell length should be $\sim 10^2$ cm.

The described nonlinear coherent effect can thus be used to shape high-power ultrashort light pulses with durations $\tau_p \lesssim 10^{-14}$ sec^{-1}.

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ANISOTROPY OF THE HYEPRFINE INTERACTION IN SINGLE-CRYSTAL $Al(NO_3)_3 \cdot 9H_2O:Fe^{3+}$

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We report the results of an investigation of the Mossbauer effect on Fe^{57} impurity nuclei in single-crystal $Al(NO_3)_3 \cdot 9H_2O$. A sharp orientational dependence of the hfs splitting is observed, for the first time, in a weak external magnetic field H = 300 Oe.

The hyperfine structure (hfs) of the Mossbauer line in a paramagnet, having in general a more complicated form than in magnetically-ordered substances, is extremely sensitive to weak external magnetic fields [1 - 4]. This sensitivity is due to the fact that in weak fields the states of the nucleus of the paramagnetic ion are mixed electron-nuclear states, so that the nuclear transitions alter the state of the electron shell of the ion. If the interaction of the electron spin $\vec{S}$ with the magnetic field $\vec{H}$ is comparable with the hyperfine interaction, it can become directly manifest in the hfs spectrum.

The effect of the field $\vec{H}$ is known primarily as the "stabilization effect" [1], which consists in restoring the distinct hfs structure of the Mossbauer spectrum that had been smeared out by the random fields of the magnetic ions in the crystal and by external stray fields. In investigations of Fe^{57} impurity nuclei in polycrystalline samples, the stabilization effect was observed experimentally [2, 3], and these studies have demonstrated the possibility of obtaining information concerning the crystal field at the location of the Mossbauer ion.

So far, however, not a single experiment of this kind has been performed with paramagnetic single crystals, in which the hfs should depend not only on the magnitude but also on the direction of H relative to the crystallographic axes of the sample. The study of this dependence, with an aim at obtaining detailed information on the structure of the crystal field, and also at a more complete study of the relaxation phenomena in paramagnets, is in our opinion of considerable interest.